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ABSTRACT

Focusing on styles of interaction, this study investigated the possibility of sex differences in preschool children's use of the computer. A total of 21 girls and 7 boys attending a mixed-age summer preschool class chose to create drawings using an interactive computer graphics program. Observer logs, computer drawing programs, and transcribed audiotapes provided data on children's attraction to the computer, approaches to creating computer graphics, and verbalizations during computer interactions. Results showed that boys and girls were equally attracted to the computer. Discriminant analysis of the drawing data revealed that boys significantly bounced the drawing cursor off the screen borders more often, selected the draw command key more frequently, and created more right angles than did the girls. Qualitative analysis of the computer drawings indicated that the girls' designs contained more variety and greater detail than those of the boys. Girls significantly verbalized more than the boys when referring to color selection. There appeared to be an overall trend suggesting that while the girls were interacting with the computer they were more verbal than the boys. Findings were interpreted as potentially emerging, gender-differentiated approaches to using the computer. It is recommended that future research examine ways to foster such styles of child-computer interaction (Appended are a bibliography, a copy of the Delta Drawing program and instructional script, the newsletter sent to parents, a typical observer log, and some examples of preschoolers' drawings.)

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Sex Differences in Preschoolers' Use of the Computer?

A thesis

submitted by

Elsa Elisabeth Jones

In partial fulfillment of the requirements
for the degree of

Master of Arts

in

The Eliot-Pearson Department of Child Study

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ABSTRACT

Research has revealed significant differences in older girls and boys' approaches to using computers. While little research exists on young children's use of computers, findings relating to sex differences are conflicting. The present study further investigated the possibility of sex differences in preschoolers' use of the computer looking specifically at styles of interaction. Twenty-one girls and seven boys, attending a mixed-age summer preschool class, chose to create drawings using an interactive computer graphics program (Delta Drawing by Spinnaker). Observer logs, saved computer drawing programs, and transcribed audiotapes provided data on children's attraction to the computer, approaches to creating computer graphics, and verbalizations during computer interactions. Results showed that boys and girls were equally attracted to the computer. Discriminant analysis of the drawing data revealed that boys significantly bounced the drawing cursor off the screen borders more often, selected the draw command key more frequently, and created more right angles than did the girls. Qualitative analysis of the computer drawings indicated that the girls' designs contained more variety and greater detail. Girls significantly verbalized more than the boys when referring to color selection. There appeared to be an overall trend suggesting that the girls were more verbal than the boys while interacting with the computer. Findings were interpreted as potentially emerging, gender-differentiated approaches to using the computer. Future research should examine ways to foster these different styles of child-computer interaction particularly since computers will be a daily reality in young children's future lives.

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Sex Differences in Preschoolers' Use of the Computer?

COMPUTERS: Revolutionizing Our Lives

The computer is a reality that affects everyone, from the very young to the very old. While permeating the public sector of daily life, the computer is swiftly moving into the private home. In 1970, there were 11,400 jobs in computer services; that figure rose to 43,300 in 1980, nearly quadrupling what it was a decade earlier (Gilliland, 1984, p. 42). According to current predictions, a very large percentage of the labor force will be using computers directly by 1990 (Fisher, 1984, p. 24). Addressing computer education, Alvarado (1984) cited a recent report which predicted that by June 1984, 450,000 computers would be in U. S. schools and 40 to 50 million computers would be in U. S. homes (p. 15).

As this latest technological innovation revolutionizes our lives, it brings with it many promises: our abilities to think, learn, and communicate can all be enhanced through use of the computer. It affords us the opportunities to foster our creativity, to solve problems more logically and with greater efficiency, and to learn from our mistakes not by failure but through a process called "debugging." "The question to ask about the program is not whether it is right or wrong, but if it is fixable [italics added]" (Papert, 1980, p. 23). Papert speculated that 'if this way of looking at intellectual products were generalized to how the larger culture thinks about knowledge and its acquisition, we all might be less intimidated by our fears of "being wrong" ' (p. 23). It is believed that this wonderful, new tool for both thinking and learning will enable us to lead more intelligent and more productive lives.

Before exalting the computer, it is important to realize that not all that is good may result from the Computer Revolution. The unknown and potential impact of the computer on our lives warrants this an area worthy of extensive investigation. The risks, costs, and benefits associated with the increase in computer usage are not well documented. The Computer Age is still in its infancy; its novelty, intrusion into daily living, power to intimidate, and power to restructure our minds and our lives are all good reasons why we should be aware of the ways in which the computer may shape our thinking. Personal and public fears, societal and worldly concerns, educational, social and political issues exist and need to be acknowledged and addressed.

COMPUTERS IN EDUCATION: Literacy, Types of Learning, and the Need for Further Research

Along with the computer's infiltration comes the increasing pressure to become "computer literate," defined by Winkle and Mathews (1982) as "whatever a person needs to know about and be able to do with computers in order to function competently in our society" (p. 314). Anderson et al. (1984) commented that "not only is computer literacy important for success in the world of work, but it is also becoming essential for successful citizenship and useful for everyday living" (p. 10). It appears that without computer literacy, individuals will not be able to survive in the impending Information Age.

Two approaches to computer learning are "interactive" computer use and "computer assisted instruction" (CAI). The former involves the person controlling and pacing the learning experience, and the latter places the computer basically in control of the individual's learning. Focusing on children, Dr. Seymour Papert (1980), inventor of LOGO, stated that CAI entails having the "computer program the child" whereas with interactive computer use, the "child programs the computer" (1980, p. 5). Papert placed emphasis on the computer as an "object-to-think-with" (p. 11), not a tool to think for you or to tell you what to think. One of the many concerns people have with regard to the computer is the possibility of it controlling our lives and our minds; when employed in the interactive sense the chances of this occuring are greatly reduced.

Other foreseeable ill effects of human-computer interaction have been expressed in computer educational journals, popular magazines and nonempirical research. Two frequently mentioned concerns of parents and teachers fall under the headings: child becoming a computer "addict" or "isolate," and the computer being labelled a "male activity" belonging to the "hackers." Another issue is how early should the computer be introduced to children; is "too young, too soon"? These are real worries to which many desire answers. The best way to approach and answer these questions is through empirical study, however, with the computer's swiftly growing presence, there just aren't enough researchers to examine all the issues.

Sheingold (1981) emphasized the great need for further knowledge about educational computer use and its effects on children. The primary source of information on how computers were affecting school-aged children were educators' reports, which were very helpful in identifying topics for empirical investigation. Targeted as a rich area for study was the issue of social outcomes in relation to social interaction, status, and self esteem. Considered critical for study was the question, "What are children learning by interacting with the computer?" Sheingold reported that no one really knew about the educational or developmental consequences for children of using microcomputers, and not because the teachers hadn't read an abundant research literature, but because there was almost no literature to read (p. 16-17). Regardless of whether further knowledge was acquired through research, Sheingold contended that the computer was an innovation which was going to continue to proliferate our educational and societal institutions.

Three years later, substantial information has been obtained, however, much of the computer literature has not been written by researchers and is primarily in the form of anecdotal accounts, speculation, and editorializing. There remains a paucity of empirical research literature on the educational and developmental consequences for children interacting with computers. The fact that we need more research on the topic of children and computers (and the computer's impact on people) is stressed in the educational journals, popular computer magazines, teachers' observational studies and anecdotal reports, parents' letters requesting information and aid, and several other sources. We are already aware that the computer is going to radically change our lives. We need to know in what ways and how we can best prepare ourselves and our children for the destined computer culture.

COMPUTERS IN EARLY CHILDHOOD EDUCATION:
Implementation, Software Selection, and Child Development Issues

Because computers in education are still very new, educators have yet to decipher all the issues regarding successful implementation of this learning tool into the curriculum. As mentioned earlier, a question of concern, to not only teachers but parents as well, is how early the computer should be introduced to children. That the computer is not only a part of the adult world but has a significantly increasing role in the child's life is something about which parents and teachers of young children are reminded daily. There is tremendous pressure to introduce young children to the Information Age. Society is being bombarded with all kinds of computer information, popular literature, and advertisement.

A current commercial on television, "Alfie the Friendly Computer," pushes the message that children as young as three years of age should be exposed to the computer. The benefits of this experience will be "programming preschoolers" engaging in "self-paced, increasingly challenging" computer activity. This, no doubt, puts parents and teachers in awkward positions, and may present to them the (up-until-now-absent) notion that their children could be left behind if parents and teachers do not take heed.

Stechery (1984) discussed the early childhood educators' debate on whether computers have a place in the preschool classroom. On the one

hand, it is believed that computers are too abstract to have a place in the lives of preschoolers. While on the other hand, it is argued that the sooner children become acquainted with the equipment the better. However, there appears to be one point of general consensus and it is that "computers should be just a small part of the three- to five-year-old's world" (p. 72), regardless of how important computers will be to today's children as they grow up tomorrow.

The decision to implement computers into the preschool entails a great deal of thought, considerable research, and critical evaluation of the early childhood goals and values. Another problem involved in the introducing of children to computers is the selection of appropriate hardware and software. In the education of young children, the software is actually more important than the hardware in that the type of computer program used plays a crucial role in the child's acceptance of the computer as a learning tool. Aware of the distinction between interactive computer use and CAI, it appears that the former may be more beneficial to the developing child in that it allows the child to have control over his or her learning experience rather than being controlled by it.

In her research on "Software for Kids," Stechery (1984) reported that the number of software publishers developing educational programs, or "learning games" as they are called, is on the rise. These programs offer much more than rote, drill, and practice which, according to Stechery, young children do not really need. 'Preschoolers are not memorizing; they're "playing" [italics added] and exploring' (p. 72).

Piaget's concept of child play and its importance in the young child's cognitive development is relevant to the topic of children and computers. The Piagetian model of cognitive functioning emphasizes the "adaptation" of a complex organism to a complex environment. Cognitive adaptation involves two simultaneous and complementary processes, "assimilation" and accommodation." The former refers to the taking in of external stimuli and adapting it to one's internal mental structures; the latter to the adapting of mental structures to the structure of the external stimuli (Flavell, 1977, p. 7). "Play" is an assimilative behavior. "The child absorbs the new into the old and constructs his knowledge in the course of actively working with it" (Papert, 1980, p.120). Piaget viewed children as "builders of their own intellectual structures" (Papert, p. 7), and believed learning and life to be active rather than passive experiences.

Relating this to the computer, interactive programs allow the child to engage in conceptual learning and procedural thinking. He or she learns how to program the computer, and is, therefore, an active learner. CAI, on the other hand, emphasizes tutorial learning, and drill and practice. The child is programmed by the computer and is, in essence, a passive learner. Interactive computer use may better assist the young child in building his or her own intelligence.

Clearly, the computer does tap into the development of the young child and has a place in the preschool classroom. The potential for the young computer user, both present and future, is overwhelming. Surrounding the

decision to implement the computer into the preschool curriculum is the major task of adhering to and facilitating preschool educational goals and values.

Nieboer (1983) assessed the appropriateness of the computer as a basic learning tool in the preschool by examining whether or not it met the general goals of preschool education. Her findings indicated that the computer contributed to fine, but not gross, motor development through use of joystick and keyboard controls. Social development was facilitated through developing the ability to take turns, however, personal interaction with the computer did not lend itself to social interaction around the computer. It was uncertain whether language development was promoted through computer experience because as children concentrated on their creations, verbalizations were few and brief. Although, when they chose to discuss their work with the researcher or observing peers, their language was "very full and rich in imaginative and descriptive detail" (p. 26). Cognitive development was enhanced through creative activity and problem solving behavior, and emotional development was fostered through success and pride in achievement. Lastly, Nieboer reported that the computer broadened the young child's present experience base while preparing him or her for the future.

The computer should be an additional learning tool in the early childhood classroom -- a creative medium similar to art, blocks, sand and water. In the words of Stechery (1984), the computer should be "something worth exploring and learning from, along with the sandbox, the kitchen cupboard and the cat's bushy tail" (p. 72). In early childhood

education, emphasis is placed on the young child's overall development. It is imperative that the computer take its place beside the other basic learning tools, and contribute to, not subtract from nor be the panacea for, the nurturing of positive development of the child.

COMPUTER EQUITY IN EDUCATION:

The Problem of Inequity

A major issue which must be dealt with is that of "computer equity" in education. Research has revealed that there are inequities in educational computer access and usage, and that they are by no means nominal. Prevalent discrimination has been found in the availability and use of classroom computers on the bases of economics, sex, race, special needs, type of school district and community, and geographical region.

A recent study by the National Science Foundation found that 31% of the students in affluent urban areas have access to computers in schools as contrasted with only 12% of their counterparts in rural areas. The study further revealed that disadvantaged students and females are much less likely to have ready access to computers in schools (Komoski, 1984, p. 5).

The Johns Hopkins University Center for Social Organization of Schools conducted a national survey that yielded several findings in support of the inequity hypothesis. Henry Becker, the Director of the John Hopkins study, reported that the poorer and most traditional schools are least likely to have microcomputers. While nearly 90% of all public secondary schools have a least one microcomputer, less than 65% of secondary schools with predominantly minority school populations and/or low socioeconomic status populations have them (Lipkin, 1984, p. 19).

In April 1984, Alvarado brought our attention to the existence of an "intellectual gap." It was reported in the Christian Science Monitor that while wealthy schools tend to use computers to teach advanced skills such as programming, inner city and rural schools are more likely to simply drill students in the three "R's" (p. 15). Alvarado commented that "while one group learns to use the computer as a powerful intellectual tool, the other learns to use the computer simply as an instructional delivery system" (p. 15).

Focusing in on the computer-use sex discrepancy, Campbell (1983, p. 4) reported that while half of the students in any district or school with computers are female, half of the computer users are not. Females constitute less than one-third of the students learning about computing. The proportion of males to females attending private computer camps and after-school programs is estimated to range from 8:1 to 3:1. Campbell also found that even when girls are involved with computers, they have a tendency to be clustered in beginning and general courses, rather than the more advanced courses. Fisher (1984) alerted us to the finding that boys are more likely to be given access to computers at home (p. 24).

The gravity of these disparities in computer education is apparent; they must be overcome. The possibility of further dividing our society into the "computer literates" and the "computer illiterates" is well in the making. Komoski (1984) informed us of the deeper issues involved: "The undeniable truth is that the specific issue of access to computers simply reflects the long-standing historical inequities operating within American education in general" (p. 5). Komoski further emphasized that inequity

extends well beyond the issue of computer availability and usage within the educational system; inequity is a societal problem. The potential of the computer in our society is enormous, however, it can serve to further exacerbate the division between the haves and the have nots if attempts are not made to address the larger social truth surrounding the educational problem.

Evidently, the issues are much larger than they appear. The promises for a more intellectual and creative future are not meant for our entire society, so it would seem according to the above statistics. Efforts must be made to eradicate these various discriminative practices in computer education, before the computer bandwagon leaves the majority, not the minority, of society behind. With respect to computer education and equity for the sexes, girls need to know that computers are for them also.

COMPUTER USE AND SEX DIFFERENCES:

High School to Preschool

Of primary interest to this researcher is the issue of sex differences in preschool children's use of the computer. That sex inequities are pervasive in our society is historical, political, and heated news. According to the statistics presented on computer equity, it appears that the computer is moving toward becoming another perpetuator of the gender gap. The questions to be asked are: What will this mean for society?; What are the implications for young children?

Many factors account for the sex differences in the use of computers, some are as follows: social stereotypes, societal attitudes, particularly those of parents and tachers, sexist software, and technophobia. Some might even argue that biology plays a role. Whatever the cause or causes, the resulting effect is that while girls are initially as interested in computers as boys, somewhere down the line they shy away. Perhaps they develop "computer anxiety" or maybe they come to view the computer as math.

Winkles and Mathews (1982) reported that computers are often associated with mathematics and thus share its stereotyped characterization of being a "male domain." Computers as "number crunchers" is a common viewpoint which helps explain computer anxiety -- the idea that computers are too complex to be understood by the average woman. This anxiety not only keeps women out of technological fields, but also discourages them from even developing their knowledge of computers (Winkle and Mathews, p. 315).

In addition to the finding that girls are less interested in the computer as a math experience, it has been discovered that girls truly enjoy the computer if it relates to areas that they find more attractive, e.g., art, music, people (Strausberg, 1984, p. 56). Software that is similar to popular video games with themes of violence, aggression, and destruction simply does not appeal to girls (Campbell, 1983, p. 1). Campbell studied video games and reported that in most of these games, and also in educational software based on video games, users learn to stave off defeat and develop mastery in prolonging their inevitable doom. However, no matter how long the user holds off failure, "success is impossible." Campbell emphasized that, "the message that you can't succeed is one that young women and minorities get far too often" (1984, p. 12).

Other reasons offered for girls retreating from the computer are that they aren't aggressive enough or that they have no female role models. The sad fact is that too many girls are relinquishing the computer to the boys, thus playing a part in its becoming the "male" computer. In the words of Lockheed and Frakt (1984). 'By male self selection and female default, the computer becomes defined as "male turf" -- as socially inappropriate to girls as the boys' locker room' (p. 16-17).

The possibility of the computer becoming a tool by which sex discrimination can occur has many implications for our present and future society. Take for example, the common finding that during secondary school the majority of males and females are taking different computer paths: By high school, it is not uncommon to find that over 70 percent of the

students in the programming classes are males, while girls predominate in the word processing classes (Fisher, 1984, p. 28). The picture becomes even more poignant when we look at it in Sander's terms, "The computer-use sex discrepancy matters because it turns into an economic sex discrepancy when today's children grow up into tomorrow's adults" (1984, p. 31).

There is tremendous irony and regret in high school girls' avoidance of programming courses and technical careers, especially in light of the fact that although Charles Babbage was the "father" of computers, the first computer programmer was a woman, Lady Ada Lovelace (Campbell, 1983, p. 2).

More obvious is the following irony:

> ... the computer is intrinsically nondiscriminatory. It does not pass judgment on its users; it does not select those who instruct and learn from it; its language is symbolic; and it is not culturally or sex biased. It provides an opportunity for overcoming any unfair practices to interested users; yet as used in many schools, the computer is the object of selective access that favors some populations at the expense of others (Schubert and Bakke, 1984, p. 28).

Considerable research (albeit not nearly enough) has been conducted on the topic of sex differences in computer access and use. With respect to gender and technology, it appears that boys are being favored at the expense of girls.

While the majority of the studies have focused on older children, particularly middle and secondary school ages, very few studies have looked at preschoolers. One reason for this may be that in the middle school studies, it has been found consistently that many girls, when approaching puberty, begin to develop the computer anxiety which Winkle and Mathews talked about. According to them, "self-inhibiting attitudes" begin to appear (p. 315). Gilligan (1984) specified "eleven years on up" as the age at which many girls, along with help from their teachers, parents, peers, the media, and other societal influences and pressures, commence a "self-effacement" process and go "underground" (p. 37). Their confidence in their technical ability, in ascent up until this point and at least comparable with that of boys, either becomes stifled or drops. As Strausberg (1984) put it, "Puberty seems to have a poisonous effect on science, math and computers" (p. 56).

Societal attitudes can also have a poisonous effect on girls' perceptions of themselves and their future career goals. The following actually happened:

> In a Wisconsin high school that doesn't have enough computers for all the students who want to use them, the principal solved the access-demand problem by announcing that computer use is reserved for the boys. Why? Because it is essential that boys obtain computer preparation for engineering careers, he said (Equal Play, 1983, p. 16).

It appears that puberty is not the only villain keeping girls out of the advanced computer courses and technical careers.

Prior to puberty, males and females appear to be equally attracted to computers. Watt (1983) cited a recent study which showed that girls are just as interested in computers as boys are. However, boys were often more aggressive in getting access to the computers. She emphasized the importance of providing equal access to the computer.

Sheingold (1981) employed the case study approach to cross-sectionally study the implementation of computers into three very different U. S. school systems. Looking at both the elementary and high school levels, her findings for the three school systems were consistent: At the elementary level each sex could and did use the microcomputer more or less equally. However, beginning in 7th grade, "there was an overwhelmingly male representation among students who use the microcomputers" (p. 14). In the teachers' reports to Sheingold it was mentioned that students often experienced gains in self esteem through learning how to use the computer and were then able to help others. This increase in self esteem is frequently reported by teachers, and is an important and positive outcome of early computer experience, especially if it occurs before the girls reach puberty.

Licht and Dweck (1983) conducted an extensive review of the literature on sex differences in achievement orientations. Having studied children in preschool through high school, they reported that males and females have very different achievement-related beliefs which in turn positively affect the former's intellectual performance and negatively affect the latter's. One of their most intriguing findings was that girls, relative to boys, have less confidence in their ability to succeed on challenging intellectual tasks. This pattern was found to emerge during the preschool

and early school years despite the fact that girls consistently perform as well as, if not better than, boys during these years across a variety of achievement domains. Licht and Dweck commented that, "Girls' lower level of confidence is of great interest not only because it seems unrealistic, but because it appears to have a detrimental effect in the long run on girls' intellectual accomplishments (p. 1). These findings tend to suggest that girls' self-effacement can start much earlier than puberty, and possibly as early as the preschool years. It would be interesting to study children's self-confidence in their ability to use computers.

In light of the opposing findings on boys and girls' equal use of the computer during the elementary years versus the greater interest and use by males in the middle through upper school years, it would seem logical to hypothesize that there are no sex differences in children's computer use at the preschool level. Assuming that teachers and parents will keep their biased opinions from young children, and knowing that puberty has yet to set in, the computer should be a nonsexist learning tool for the preschool child. In fact, this is primarily what the majority of the handful of studies on this topic shows.

Piestrup (1982) studied children as young as three years of age using computer graphics to gain spatial and pre-reading concepts. It was found that boys and girls asked for turns equally. Piestrup stated that even though children readily identify boys' activities and girls' activities at the preschool level, there was no sense that the computer was a "boy's domain" in this preschool class.

Reed (1983) reported that sex differences in computer use do not exist

at the preschool level. This conclusion was based on an interview with Professor Pat Dickson of the University of Wisconsin who is involved in research on the impact of the microcomputer on young children. Dickson reported that preschool boys and girls' equal use of the computer is tied directly to the software. Educational software for young children does not resemble the video game theme of space wars involving violence and destruction, something which many older girls find "boring." This video game type of software has yet to be developed for preschoolers, and as long as teachers or parents provide good software and a supportive environment, according to Dickson, girls are likely to be just as interested in the computer as boys are.

Swigger et al. (1983) investigated preschool children's preferences for different types of CAI programs. They did not find any significant sex differences in three- to five-year-old children's number of visits to the computer and the amount of time spent on the computer.

Nieboer (1983) utilized a computer graphics program to study the effect of computers on the preschool environment. She found that four-year-old boys and girls, from families connected with the U. S. Air Force Base in Michigan, interacted equally with the computer in terms of number of computer visits and length of child-computer interactions.

Two studies conducted by Lipinski et al. (1984) looked at gender, competence and free-play areas and how they affect microcomputer use by four-year-olds. The children participating in the first study attended a university-based nursery school; those in the second study, a university day care center. Software teaching the alphabet, numbers, shapes and

opposites was used in both studies. It was found that girls in Study I spent significantly more time at the computers than the boys, while in Study II, no significant sex differences were reported. Despite the sex differences found in the first study, the researchers concluded that the microcomputer was a "fairly egalitarian play object for these children." They noted,'If indeed the microcomputer has not been sex-typed at the preschool level, it behooves educators to consider introducing the computers to preschoolers before the computer acquires this "male-only" sex typing' (p. 13).

Despite what these few studies show, they do not rule out the possibility of the computer being sex typed a "male activity" at the preschool level. As the Computer Age settles in, and if the computer gender gap continues to increase, very young children may not have to wait until puberty to deal with computer sex inequity. That is to say, a new social stereotype may be emerging. This may result in giving different messages to young boys and girls about the computer's intended purposes and their future roles in the world of computers.

Maccoby and Jacklin (1974) reported that sex typing of certain classroom activities occurs as early as the preschool level, and may be due to children relating those activities to masculine or feminine roles. They presented findings from numerous studies on preschool children's toy and activity preferences. Two frequently cited findings were that blocks were often thought of as "boyish" toys, and art activities were preferred by girls (p. 278-281). In their discussion of these sex-typed toys and preferences, Maccoby and Jacklin speculated on the following:

> if these activites become labeled as more appropriate for one sex, then, it seems possible that it is because children of one sex choose to do them rather than vice versa. However, by preschool age [italics added], differentiation may be seen that does clearly relate to adult sex-typed activities (p. 279).

Their last point ties in with the computer becoming an adult sex-typed activity and what that can mean for young preschool children. It is possible that the computer may be typed a "male activity" at the preschool level.

Empirical evidence on mastery motivation in young children can be applied to the possibility of early sex differentiation in the use of computers. Molnar and Weisz (1981) studied mastery motivation in preschool boys and girls. Their results, consistent with earlier findings, showed that older preschool boys (4/7 to 5/7 years) were more mastery oriented than their female counterparts. Younger preschool children (2/8 to 4/7 years) did not show any sex differences in their pursuit of mastery. Also very interesting, and in line with Licht and Dweck's work (1983), of the four groups, the older girls were least likely to complete the tasks they did attempt. Molnar and Weisz concluded that sex differences in mastery motivation may emerge in the preschool years.

Mastery, success, empowerment -- these are all important issues for the computer user of any age. Campbell (1984) believes that, "One of the most important messages young people can learn is that they can, and

should, have some control over areas that affect them -- that they have the power to change things. Computer software can either reinforce or deny that view" (p. 12). Computers can be one of the tools through which young children hear these messages. A question of importance is whether young boys and girls are hearing the same messages.

Campbell (1983) stated that girls are being kept out of the Computer Revolution. This we know to be true based on the research literature and the statistics gathered in surveys on middle and upper school males and females. However, Campbell alerted us to the fact that sex discrimination against girls starts even earlier than the research tends to suggest. She reported, "Keeping girls away from computers starts early. In one Michigan preschool, a group of boys created a computer club and decreed that girls could not use the computers" (p. 4). This finding is not in keeping with the research presented earlier which claimed no sex differences at the preschool level; however, it is in keeping with the literature on preschool sex-typed activities. The questions to be asked are as follows: Are the preschool boys behaving this way because they really like the computer and want it to be their very own "toy"? -- or -- Are the boys responding to societal influences?; Are they somehow aware that gender inequity in computer use favors males?

A study by Beeson and Williams (1983) yielded findings contradictory to the no-sex difference hypothesis in preschoolers' computer use. The researchers investigated sex-stereotyping associated with computer use at the preschool level. The research question was, "How does gender and age affect preschool children's choice of the computer during child-select

times?" A significant interaction effect was found between gender and age in the children's choices: boys under five years chose to play with the computer three times more often than girls under five. However, there were no differences for the boys and girls above five years. These findings were contrary to what was expected; Beeson and Williams indicated that further research is needed to clarify the interaction effect found between gender and age. In their conclusion, they commented that children do learn through "cultural experiences." Perhaps sex stereotyping of the computer is taking place at the preschool level. (It was noted that Beeson and Williams did not report the type of computer program employed in their study. As discussed earlier, CAI versus interactive computer programs can have different effects on the child's decision to engage in computer activity.)

Piestrup (1981) tested a computerized reading skills program with preschool children. The children were enrolled in a university demonstration and experimental nursery school; they were three and four years old. The software used was interactive and nonsexist with male and female digitized voices. Piestrup's findings appeared to favor the girls: "More girls than boys asked for turns on the computer and persisted in getting turns." However, there were more girls than boys in the class. The researcher commented that the boys seemed less able to wait the minute or two that was necessary to start their turns. Piestrup also commented that the only time there was a significant change in the number of boys versus girls approaching the computer was when a male programmer visited. Throughout the study a woman had monitored the computer, and the preschool teachers were all women. This alerts us to the possible differential attraction of young girls and boys to their respective sex role models, and says that this may be a factor in the young child's decision to use the tool.

THESIS QUESTION

Sex Differences in Preschoolers' Use of the Computer?

In light of the conflicting research findings, research is needed that will shed further light on the subject of preschool girls and boys' use of the computer in the classroom. The present study attempted to explore this topic. Sex differences in preschoolers' computer use was believed to exist in terms of the "nature" of young boys and girls' interactive program computer experiences. There is more to the picture than children showing or not showing an interest in the computer; the "why" is very important. Also, "how" children are interacting with and experiencing the computer are both significant issues. Because many studies investigating sex differences in computer use employ as their main (and often sole) dependent variable the number of visits to the computer and/or the amount of time spent on the computer, the present thesis sought a deeper understanding of preschool girls and boys' attraction to and use of the computer.

This study looked at children's choice of the computer as a classroom activity and explored whether the computer might be used in different ways or styles by boys and girls. For example, while interacting with the computer, are the verbalizations of girls different from that of boys? Are boys creating computer designs that are different from the girls? What types of experiences are the children having? -- and, do they differ in terms of gender?

A brief mention of a study conducted by Pretl (reported by Frank,

1983) points to the significance of investigating boys and girls' styles of interacting with the computer. Thirty-nine children between the ages of five and seven years were trained equally to use nonagressive, noncompetitive, and nonviolent computer games in the same school system. Despite their being equally matched, it was found that the boys and girls approached the same computer tasks and capabilities in distinctly sex-differentiated ways. Boys learned to master the "Repeat" command using it with large numbers and thus covering their screens quickly and efficiently with relatively few commands. Girls, on the other hand, also learned how to use the Repeat command, however, their patterns were created slowly and painstakingly by "repeating" many, very small numbers. Frank reported that the girls' designs were far more intricate than those created by the boys. Moreover, whereas the boys quickly completed their programs, the girls fussed with theirs, "perfecting them by adding more detail" (p. 13). Frank offered as an example the fact that girls would color in their programs. The concluding question posed by Frank was whether gender differences in style of using the "tool of tomorrow" could be attributed to inherent sex differences or differential socialization. She also commented that these types of gender differences, females perfecting things while males tackle and move on, are by no means unique to the onset of the Technology Age.

The findings of the Pretl study added support to this researcher's belief that much could be learned through looking at the "nature" of boys and girls' computer experiences. Their decision to use the tool, the dialogue/language accompanying the interaction (although verbalizations

were expected to occur infrequently due to the child concentrating on his or her computer creation), and the kinds of computer drawings produced were the variables studied. Also considered very important was the process involved in creating the computer graphics designs. Sex differences, not necessarily in choice or interest, but in the nature and style of the computer interactions, were expected. Individual differences, however, were expected to be equally, if not more, significant.

The software employed in this study was "Delta Drawing," a nonsexist (Campbell, 1983, p. 6), interactive computer graphics program. By using simple, single-keyboard commands, the child directs a triangular-shaped cursor, the "delta," around the television monitor's screen. For example, the child presses "D" to "draw," "R" or "L" to turn "right" or "left" respectively, and "C" to select a "color" from a menu of five different colors. The child can also choose to color in, "Fill," a closed space. The program is always put into the bounce mode (as opposed to wrap) which causes the delta to bounce off the borders of the drawing screen. (For a complete description of the Delta Drawing program commands taught to the children, see Appendix A.)

Based on a pilot of this thesis study and David Alexander's ongoing research on children's Delta Drawing experiences and creations, the following qualitative impressions were formed:

1. While boys and girls appear to be equally attracted to the computer, girls seem to spend more time at the computer.

2. During the drawing process, girls seem to take longer creating their designs, whereas the boys appear to spend less time working on and completing their computer drawings. Boys also seem to draw with greater efficiency, e.g., use less turns to complete a right angle.

3. Looking at the computer drawings produced, girls' pictures appear to have greater detail, due primarily to what seems to be more bouncing of the delta, more filling, and a greater variety of colors. Boys' Delta drawings visually appear to contain more right angularity, that is more 90 degree turns.

4. While violet seems to be a favorite color of both girls and boys, girls appear to use more colors and fill more often.

5. With respect to children's verbalizations, impressions were that girls talk more while interacting with the computer and that they talk about both computer and non-computer related things. Boys appear to talk less often (possibly a result of the researcher's female gender), and talk mainly about the movement of the delta and the direction in which they want it to move.

The above impressions were explored in this thesis study, as further analysis, both qualitative and quantitative, was considered very important in the study of how preschoolers are using the computer and whether sex differences exist.

METHOD

Subjects.

Twenty-eight preschoolers in a class of 32 children (ten boys and 22 girls) were the subjects in this study. They were attending Summer Session II (July 1984) at the Eliot-Pearson Children's School, a university-based nursery school. The seven boys and 21 girls, all Caucasian, ranged in age from three years five months (3/5) to six years three months (6/3) with a mean age of 4.7 years (approximately four years eight-and-one-half months). Ten of the subjects were only children, while eleven were the oldest in families of two or three children. The remaining seven were either middle children or the youngest in their families.

Several of the children were from University faculty and student families, and many were from families in Medford, Massachusetts and neighboring communities (Winchester, Arlington, Somerville, Everett, Cambridge, Lexington and Revere). Information on parents' educational background was obtained for all but one family. All the mothers were high school graduates; 31% possessed college degrees and 50% graduate degrees. Fathers were all high school educated with 28% possessing college degrees and 66% graduate degrees. The children were all from two-parent families.

Prior to the start of classes, parents were sent a newsletter which informed them that the computer would be introduced to their children during the second summer session as one of the curriculum activities. Parents were allowed to observe their children while interacting with the computer from the observation booth.

Baseline information on the children's prior experience with computers was obtained directly from each participating child upon his or her initial visit to the computer. Thirteen children (57.14% of the boys and 42.86% of the girls) reported having used a computer in school; six children (14.29% of the boys and 23.81% of the girls) had computers at home; and seven children (42.86% of the boys and 19.05% of the girls) had previous experience with drawing on the computer. Four children (14.29% of the boys and 14.29% of the girls) mentioned video games experience. Note that there was some overlapping of these four categories for a few children. Ten children (28.57% of the boys and 38.95% of the girls) had no previous experience with computers and/or computer drawing.

Apparatus.

The hardware employed was an Apple II Plus computer with television monitor, disk drive, and keyboard (Electrohome model no. 38-G 12-002-01). "Delta Drawing" (available from Spinnaker Software, Cambridge, MA 02142) was the software utilized in this study.

Materials.

Audiotapes, tape recorder, and computer storage disks were used to collect the data. A classroom wall clock with a second hand was used to time to the nearest minute the duration of each child-computer interaction. On an observer log, the following were recorded: total amount of time

(total minutes) each child spent at the computer per visit, a description of the child's computer drawing, anecdotal verbalizations made by the interacting child and observing peers, and researcher's observations and comments (see Appendix B for copy of observer log).

Procedure.

The computer was one of many free-play and choice activities in the summer preschool curriculum. Four days a week, Monday through Thursday, for 14 days total, the computer was available to the children. The class was divided into two groups with 15 children attending school only in the morning (9:00 to noon) and 17 children staying on through the afternoon (until 2:00 pm). The computer was available to all the children in the morning from 9:30 to 11:45, minus 15 minutes for Meeting Time -- a total of two hours. The morning consisted of outdoor free-play followed by Meeting Time at the end of which the children selected their indoor choice activities.

Being a child development, research affiliated nursery school, the children and five preschool teachers were accustomed to research procedures and to the presence of visitors in the classroom. The experimenter served as sole instructor of this specific curriculum activity. While monitoring the computer, the experimenter individually instructed each participating child on the Delta Drawing process, recorded the child's behavior on the observer log, and audiotaped the child's verbalizations during only the last four sessions while he or she interacted with the computer.

The computer was set on a cart and positioned in a semi-quiet corner of the preschool classroom across from the snack and water-play tables. The child sat on a stool which was level to the keyboard. The experimenter sat next to the child in a lower chair, within reach of the computer and the keyboard. The disk drive was operated by the experimenter only, and was not in reach of the child. Audiotaping materials were placed on a lower shelf on the cart.

There was plenty of room for other children to stand and observe the child drawing on the computer. They were encouraged to observe but not to interfere. Questions and suggestions from observing peers were allowed.

As stated, the computer was a free-play and choice activity, thus the children self-selected to use the computer. On the first day of classes, all the children were invited to draw on the computer and were told to let the "computer teacher" (experimenter) know when they wanted a turn. Every child wanting to participate was guaranteed a turn through use of a waiting list.

While the majority of the children asked for turns, a few children, mostly the younger ones, were often non-participating observers who seemed very interested but appeared too shy to ask for turns. Wanting to ensure equal access to all, the experimenter, in these rare situations, invited the child to use the computer, and added his or her name to the waiting list.

The waiting list was always followed and frequently carried over to the next day. If a child was engaged in another activity when his or her

turn came up, the child next on the list was called. When that child finished drawing on the computer, the turn was returned to the skipped child. Often the waiting list was interrupted due to the all day children going off to the gym in the late morning. In this event, the children were placed first on the waiting list for the following day.

There was no set amount of time allotted for children's computer interactions. The children, therefore, terminated their computer drawing visits on their own. However, if there was great demand to draw on the computer, according to the waiting list or the several observing peers desiring turns, the experimenter told the interacting child that he or she had only a few more minutes and thus should decide what he or she would like to do in that time. Sometimes visits were cut short because of Meeting Time or gym.

All of the participating children were given the same, though individualized, instruction on how to use the Delta Drawing program. The children were taught to use thirteen different program keys; instruction was individually paced. By the second session all of the drawing options (save one, "E" for Erase) had been introduced. Delta Drawing letters and numbers were denoted on the keyboard in the form of stickers on which the letters and numbers were written (see Appendix A for detail of Delta Drawing commands and the standard instructional script).

While interacting with the computer, the children were encouraged to verbalize their thoughts and plans about drawing. Any comments about their computer drawing ideas and plans, and the Delta's movements in relation to their plans, expectations, and surprise were written down on the observer log.

During the first three weeks of summer preschool, the children engaged in open choice drawing, creating whatever they wanted. However, they were asked to point out and name any apparent shapes, planned or incidental, in their computer designs. Often the children did not have to be asked as they spontaneously directed the researcher's attention to their shapes. The focus on recognition of shapes throughout the first ten sessions was to prepare the children for the last week of computer drawing which entailed a structured drawing task.

During sessions 11 through 14, the children were asked to draw "shapes" on the computer. The three and four year olds were requested to name and draw any one shape (and more if they liked) of their own choosing. The five and six year old children were given the choice of drawing any two shapes (and more if they desired) or a house. "House" was used as a nonsexist, alternate way to draw shapes on the computer. A house could be made by combining different shapes, for example, a square and a triangle. Drawing a house with the Delta Drawing program entails having facility with using the delta cursor to create angles, specifically, right angles.

After drawing their shapes, the children were told that they could color them in (by using the Delta Drawing color and fill commands with which they were familiar by no later than the end of their second visit to the computer). Throughout the "shapes task," the dialogue accompanying the children's computer drawing was tape recorded.

The purpose of the shapes task was to have an objective measure on which to compare the preschool girls and boys' approaches to drawing on the computer. Of primary interest was the facility with which they created

shapes, e.g., construction of right angles. Recall that one of the qualitative features of the numerous drawings reviewed prior to this study by the researcher showed that boys seem to include more right angles in their drawings than girls. It appeared that boys drew with less wasted effort than girls in terms of completing ninety degree turns in fewer turns of the delta. The imposed task was intended to objectively compare boys and girls' approaches to computer drawing.

The types of verbalizations made during the structured task, e.g., asking for help, and/or comments about the difficulty involved in creating a shape, were all recorded. If a child solicited the experimenter's help in doing the structured task, the experimenter assisted the child only after having him or her think aloud about how to create the shape or shapes he or she had chosen to draw. The Delta Drawing command, "E" for Erase was introduced to the children only during the shapes task in order to allow them to correct any mistakes which may have occurred when creating their shapes. If a child did not want to engage in or complete the task, he or she did not have to and was allowed to draw whatever he or she wanted.

Througout the 14 sessions, upon completing a computer drawing, the experimenter told the child that his or her picture would be saved (both the graphic picture and the text which shows the drawing process), and that it would be available for him or her to see again at a later time. Before leaving the computer, the child was told the number of his or her computer picture. The experimenter instructed the child to press that number twice, first to close the computer drawing, and second to view the replay of his or her drawing. At the end of every visit, the experimenter thanked the child for drawing on the computer, and asked if he or she enjoyed the computer drawing experience.

Some parents were interested in observing their children interacting with the computer. When requested, parents were shown the replay of their children's computer drawings.

STATISTICAL ANALYSIS

Several dependent variables were used in this study; they were as follows:

1. child's choice to draw on the computer;

2. number of times child chose to draw on the computer;

3. amount of time (in minutes) spent at the computer per visit;

4. the drawing process: twelve Delta Drawing commands (one of the 13 was not recorded by the text, i.e., "E" for Erase) and the frequency of selection, and total frequency of all Delta Drawing commands chosen per drawing;

5. frequency of bounce (determined by recalling each picture and counting the number of times the Delta bounced off the borders of the drawing screen);

6. frequency of right angles (determined by calling up each picture and watching and recording the child's creations of right angles with the Delta). The stored text of each drawing verified the number of right angles per drawing, which were reported in the form of 3R or 3L, right and left turn respectively, and any increments by 12, i.e.,15R, 27L);

7. the drawing product: picture created; and

8. children's verbalizations: spontaneous statements per visit, recorded on audiotape and observer log.

Discriminant analysis was the major statistical procedure employed to identify the variables which best discriminated the two levels of the independent variable, that is, significantly separated the boys from the girls. Simple t-tests examined the significance of male-female differences between time spent on free choice drawing, time spent on the shapes task, and total Delta Drawing commands used per picture per visit. Pearson Product Moment Correlations were calculated to examine the relationships between the following: 1. Delta Drawing command options (for the purpose of identifying discriminating variables), and 2. children's total visits out of total days in schools (varied from child to child, maximum total school days possible equaled 14) and repeat visits to the computer.

The data, initially in the form of frequencies, were converted to proportions due to the varying amounts of time spent at the computer per child and varying total visits as well as varying total school days per child. The proportions were derived by performing the following calculations: 1. Delta Drawing commands divided by interaction time, and 2. total visits divided by total school days per child .

RESULTS

In analyzing the drawing data, concentration was placed on Visit I and the Shapes task for the following two reasons:

1. the number of visits per child varied, thus Visit I was the only time when all of the subjects were present (however, the data for two girls, their computer drawings and accompanying text, were lost); and
2. the shapes task was designed as a comparative measure for looking at girls' versus boys' approaches to a computer drawing task.

The decision to engage in the shapes task was up to the individual child. No mention of the imposed drawing project was given to the children prior to their coming to the computer. There was no control for visit, that is, for some children it was their second turn on the computer, and for others, their third and fourth.

Twenty-eight children, seven boys and 21 girls, in the preschool summer class chose to interact with the computer a total of 77 times. Ranging from one to four total visits, the mean number of interactions per child over the 14 sessions was 2.75; the mode was 2.0 interactions. The girls averaged 2.81 visits to the computer, while the boys averaged 2.57 turns on the computer.

Eighteen children, six boys and twelve girls, created shapes on the computer. Three- and four-year-olds all drew at least one shape with a maximum of five shapes, and the five- and six-year-old children drew

a minimum of one shape to a maximum of three shapes. Three children, one girl and two boys, attempted to draw shapes but afterwards chose to create their own designs. None of the five- and six-year-olds chose to create a house on the computer using the Delta Drawing program.

Over both open-choice drawing and structured drawing, the interactions ranged in time from four to 22 minutes. Girls averaged 12.0 minutes on Visit I and the boys, 11.86 minutes. Separating out the shapes task data, the girls spent an average of 14.17 minutes completing the shapes task while the boys were engaged in creating shapes on the computer for an average of 13.50 minutes.

Quantitative analysis employing the T-test method indicated non-significant differences for the following: 1. the preschool boys and girls' average visits to the computer, 2. the average amount of time spent by both sexes drawing freely on the computer, and 3. the average amount of time spent by both sexes while engaged in the structured computer graphics task.

T-tests were performed on the total frequency of all Delta Drawing commands selected by boys and girls during Visit I and the shapes task. The totals were adjusted for varying duration of interaction time. Although the results were non-significant, there was some indication of a trend: Upon Visit I, the mean Delta Drawing commands chosen by boys equaled 23.86, the mean for girls was 17.70. However, the shapes task data revealed the opposite; girls used more Delta Drawing commands in creating their shapes than did boys, $\bar{X}$ = 35.48 and 29.67, respectively.

Looking at Visit I data (see Table 1) apart from the shapes data, Pearson Product Moment Correlations identified as most significant the relationship between the frequency ratios for Bounce and Draw. For girls, $r = 0.67$, $p < .005$; boys, $r = 0.98$, $p < .001$; and girls and boys together, $r = 0.85$, $p < .0001$. Discriminant analysis was employed to further investigate this relationship and thus revealed Bounce as the only Delta Drawing component which best discriminated the boys from the girls. Boys bounced the Delta almost three times as often as girls, ($\bar{M} = 1.12$ for boys, $\bar{M} = 0.44$ for girls) $F(1,24) = 11.99$, $p < .005$ [Wilk's lambda (1,24) = 0.666801).

Table 1

Visit I Data Discriminated on Sex of Child

	Girls n=19	Boys n=7
Child-Computer Interaction Time	M = 12.00* SD = 4.63*	M = 11.86 SD = 4.06
Bounces per minute	M = 0.44 SD = 0.41	M = 1.12 SD = 0.55
Draws per minute	M = 8.73 SD = 5.24	M =16.11 SD = 7.26
Total Delta Drawing commands per minute	M = 17.70 SD = 8.87	M = 23.86 SD = 7.37

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* Mean and standard deviation were calculated with an n=21. The data for the two girls were maintained for this category.

Turning to the Shapes task data (refer to Table 2), again Bounce and Draw were most significantly related for girls, boys, and the two sexes together (r = 0.63, $p < .05$; r = 0.97, $p = .001$; and r = 0.87, $p < .001$, respectively). Other significant relationships noted were that for girls as the number of colors selected increased so did the selection of violet (r = 0.81, $p = .001$); a trend was revealed for boys in selecting the color green, r = 0.78, $p < .1$). For both boys and girls, there appeared to be a negative relationship between the selections of Right and Left in the turning of the delta; boys, r = -0.75, $p < .1$; girls, r = -0.55, $p < .1$; sexes combined, r = -0.57, $p = .01$.

Discriminant analysis of the shapes task data confirmed the significant relationship between Bounce and Draw by showing that when these two variables, along with Right angles, are sifted out from all the other Delta Drawing command options, they best separate the boys from the girls. The boys averaged more bounces, draws, and right angles per minute than the girls, F (3, 14) = 4.51, $p < .05$ [Wilk's lambda (1, 16) = 0.508268].

Table 2

Shapes Task Data Discriminated on Sex of Child

	Girls n=12	Boys n=6
Child-Computer Interaction Time	M = 14.17 SD = 4.17	M = 13.50 SD = 3.94
Bounces per minute	M = 0.11 SD = 0.15	M = 0.44 SD = 0.33
Draws per minute	M = 5.35 SD = 2.72	M = 8.73 SD = 5.54
Right angles per minute	M = 0.32 SD = 0.25	M = 0.39 SD = 0.33
Total Delta Drawing commands per minute	M = 35.48 SD = 6.70	M = 29.67 SD = 9.86

A Discriminant analysis was conducted to differentiate the sample of children according to the number of turns they had drawing on the computer and whether with more visits and more experience, facility in creating shapes was enhanced. Two discriminant functions were obtained: Bounce was the major discriminating factor [F (2, 15) = 3.84, $p < .05$; Wilk's lambda (2, 15) = 0.661470]. Draw taken with Bounce and Right turns was the second significant discriminant function [F (3,13) = 2.25, p = .07; Wilk's lambda (2, 15) = 0.433803]. As shown in Table 3, the results from this test

indicated that children who visited the computer only twice bounced the delta more often, chose Draw more frequently, and used the right turn key more than the left, in doing the shapes task.

Table 3

Means for Shapes Task Discriminated on Number of Visits to the Computer

	Second Visit n = 4	Third Visit n = 7	Fourth Visit n = 7
Bounces per minute	M = 0.60 SD= 0.39	M = 0.16 SD= 0.19	M = 0.13 SD= 0.14
Draws per minute	M =10.44 SD= 6.11	M = 4.61 SD= 1.77	M = 6.09 SD= 3.18
Right turns per minute	M = 3.91 SD= 3.51	M = 3.79 SD= 5.01	M = 1.68 SD= 1.85

A One-Way Analysis of Variance of the data from the shapes task supported the finding that the variables Bounce and Draw differentiate the children who returned to the computer once from those who returned two or three times after the initial visit. The analysis of variance indicated a significant effect for second-time visitors bouncing the delta more often [F (2, 17) = 3.84, $p < .05$], and selecting draw more frequently [F (2, 17) = 3.46, $p = .06$]. There was indication of a trend for second-time visitors

selecting the color green more often than third- and fourth-time visitors to the computer [F (2, 17) = 2.75, $p < .1$].

With regard to the number of times children chose to interact with the computer, a Pearson Product Moment Correlation was calculated to determine whether the number of days that a child was in school had any relation to the total number of visits he or she made to the computer. Although a nonsignificant negative correlation was found between total days in school and total visits, this negative correlation suggests that the number of days present did not determine the number of child-computer interactions.

Further, qualitative, analysis of the drawing data will follow in the Discussion. Having looked at the process of using Delta Drawing to create computer graphics (by quantitatively examining the specific text for all pictures from Visit I and the Shapes Task), attention will be given to the computer products, that is, what the Delta Drawing pictures looked like and the ways in which the preschool boys and girls were alike and different.

Quantitative analysis of children's verbalizations involved devising categories for the types of spontaneous statements children made during the shapes task, and then coding the transcripts. The following categories were created:

I. Computer-related verbalizations:
   a. Drawing Plans, which included comments on how to move the delta, and how to create shapes, e.g., "I want to turn the delta this way.";

b. Description of the Delta's movements, e.g., "It's going back up.";

c. Color and Fill reference;

d. Animistic comments, i.e., giving life to the computer or the delta, e.g., "It didn't hear me."

e. Video game terminology, e.g., "Blast off!";

f. Bids for "Help" from the experimenter; and

g. Miscellaneous remarks, such as, "It's pretty."; "Wow!; and "All done."

II. Noncomputer-related verbalizations -- an example of this is the child telling a story to the experimenter and not paying attention to the computer.

In coding the children's verbalizations, inter-rater reliability was obtained on 33% of the 18 children's computer-interaction dialogues. The researcher and an undergraduate student were the raters. An intraclass correlation was calculated (Guilford and Fruchter, 1973, p. 263), and a correlation of .87 was obtained between the two raters. In the statistical analysis, the category, "Video Game terminology," was dropped because none of the children made any comments fitting that category. (However, the observer logs contain cases of children ascribing video game sound effects to the delta's movements during computer visits prior to the shapes task. This anecdotal material will be presented qualitatively in the discussion of the results.)

T-tests were performed on both the total spontaneous statements per minute, and the categorical verbalizations per minute. Note that the categorical data were initially in the form of proportions, that is, total

statements per category over total spontaneous statements. Statistical analysis did not reveal significant findings for spontaneous statements as a whole, however, there was one significant difference between the means for girls and boys in the Color-Fill category. Girls averaged 0.21 statements per minute while boys averaged 0.10 statements per minute on the topic of coloring and filling [F (1, 16) = 8.29, $p < .05$].

As Table 4 shows, in spite of the 2:1 ratio in favor of girls involved in the shapes task, the boys averaged more spontaneous verbalizations per minute than the girls. However, the difference is very slight and non-significant. Moreover, despite what the total means show, a look at the individual categories reveals that the girls averaged more categorical statements per minute than the boys for all save one category. Asking the experimenter for assistance was the one verbal category in which the male preschoolers barely surpassed their female counterparts. It must be kept in mind that these differences are very small and all but one were nonsignificant.

Table 4

Spontaneous Statements by Girls and Boys during Shapes Task

	Girls n=12	Boys n=6
Total spontaneous statements per minute	M = 1.035 SD= 1.289	M = 1.588 SD= 1.424
COMPUTER-RELATED STATEMENTS		
Drawing Plans per minute	M = 0.047 SD= 0.043	M = 0.045 SD= 0.112
Color & Fill comments per minute	M = 0.206 SD= 0.243	M = 0.102 SD= 0.084
Drawing descriptions per minute	M = 0.111 SD= 0.143	M = 0.091 SD= 0.112
Animistic statements per minute	M = 0.146 SD= 0.152	M = 0.113 SD= 0.132
Bids for Help per minute	M = 0.078 SD= 0.144	M = 0.081 SD= 0.108
Miscellaneous statements per minute	M = 0.010 SD= 0.034	M = 0.000 SD= 0.000
NON-COMPUTER RELATED STATEMENTS per minute	M = 0.126 SD= 0.138	M = 0.053 SD= 0.120

DISCUSSION

Quantitative analysis of both the drawing data and the children's verbalizations served to support as well as dispel some of the qualitative impressions formed prior to conducting the present study. In discussing the quantitative results, findings will be interpreted in light of the qualitative impressions.

The statistics revealed that boys and girls are doing different things in their computer interactions, however, there were greater similarities than differences. Despite the three to one ratio of study sample in favor of girls, both boys and girls were equally attracted to the computer, and on the average, there were no sex differences in computer-interaction time. Both males and females interacted equally with the computer in terms of the number of visits to the computer and the amount of time engaged in both open and structured computer drawing activity. It was indicated that the number of days in school did not influence who came to the computer; in other words, those children who participated in drawing on the computer did so because they were attracted to the computer experience.

The belief that when drawing on the computer boys created more right angles than the girls (stemming from the visual appearance of children's Delta drawings) was supported. The findings that boys had the delta bouncing more often than did the girls, and that they selected the draw key more frequently than the girls, were contradictory to what was impressionistically believed to be true which was that girls had the delta bouncing more frequently and selected the Draw key more often. It

should be noted that while Bounce was the major function discriminating the sexes, it cannot really be separated from Draw, the other significant discriminating factor. The reason for this is that in the Delta Drawing program in order for the delta to bounce off the borders of the screen, it must either be "drawn" (D) or moved (M) up to the edges of the drawing screen. Thus, it makes sense that Bounce and Draw were significantly related.

Upon looking at the computer drawings, many of the girls' creations appear to be more detailed and to have more variety than the boys' designs in terms of more colors, more bounces, and more fills. Qualitatively and subjectively speaking, if the drawings could be characterized by sex, boys' computer drawings may be said to fall into the category of "geometric architecture" (Alexander, spring 1984), which looks like a block construction of squares and rectangles, vertical and horizontal lines intersected by right angles. (An example of boys' geometric architecture on the computer may be seen in Appendix D.)

The gestalt of the boys' computer graphic creations primarily consists of straight lines, right angles and very few colors. The girls' computer designs, however, take several forms, the predominant one being the "argyle" pattern (Alexander, 1984) with many colors, a lot of filling, and a lot of angular bouncing. (See Appendix D for an example of the girls' argyle pattern.) This is not to say that boys do not create diamonds and triangles, and that girls do not make squares and rectangles when drawing with the delta. Clearly, the statistics show that boys are bouncing the delta more than girls, however, their

form of bouncing is disguised in that it is rectilinear whereas that most commonly found in the girls' drawings is angular.

Turning to the shapes task, the shape that the majority of the children wanted to draw first was the circle (not surprising since this is the first shape children learn how to naturally draw). However, the circle is the most difficult shape to draw with the delta. Thus, after attempting at least one other shape first, the experimenter then assisted the child in drawing a circle. Several children chose to draw squares, rectangles, and triangles; one girl created a diamond with the researcher's assistance. Note that there was no control for the shapes children drew on the computer; thus, interpretation of the results are limited because not all of the eighteen subjects chose to draw the same shape(s), and certain shapes require greater skill than others.

Statistical analysis revealed that facility in drawing shapes was fostered through experience with drawing on the computer, and that the visit on which a child did his or her shapes task did seem to matter. Those children who had greater experience with drawing on the computer appeared to be able to handle the drawing task more efficiently in terms of bouncing the delta off the screen borders less frequently and using fewer commands to create their shapes.

A final point about the computer drawing task involves the reported trend which showed that boys averaged a greater number of Delta Drawing commands than the girls in their initial visit to the computer while the girls averaged more Delta Drawing options per unit of time than the boys

when creating shapes. This may suggest that boys were able to handle the structured task more efficiently, that is, they might have been able to create their shapes with less wasted effort, in terms of fewer commands. It would be interesting to know how many children, both boys and girls, made use of the erase key in order to correct their shapes. While the selection of this key is not recorded in the saved text, everytime the E key is pressed it erases from the text the previously selected drawing command, therefore subtracting from the total number of commands used in creating the design. Perhaps some of the children made more use of this drawing option than others, thus distorting the true averaged totals.

Quantitative analysis of the children's verbalizations revealed only one significant finding which was that girls were more verbal than the boys when it came to coloring and filling. However, as the means (presented in Table 4) tend to indicate, the girls, on the average, appear to have been talking more frequently than the boys; this seems to support one of the qualitative impressions regarding boys and girls' verbalizations while interacting with the computer. Also, the girls were talking about both computer and non-computer related events, whereas the average non-computer verbalizations for boys was lower than all save two of the six computer-related averaged verbalizations.

Looking specifically at the actual data from the only categorical area where boys averaged more verbalizations than the girls, it was found that two boys who did the shapes task on their second visit to the computer often asked the researcher for help in creating their computer

shapes thus making the frequency of bids for "help" high.

A glance at the anecdotal evidence from earlier computer sessions reveals the richness of the children's verbalizations while interacting with the computer (a valuable finding not depicted in the quantitative analysis of the dialogue from the shapes task). One girl called her creation a "rainbow"; one boy's was a "bed mattress." One girl wanted the delta to "crash"; and one boy wanted the delta to "go fast!" One girl talked about her "weekend trip to Vermont"; while one boy compared the computer to a "typewriter" and a "robot." One girl asked the experimenter, "Did you ever do this when you were a kid?"; at a later date the same girl stated, "Computers don't have brains, you know!"

Examination of the children's computer graphics programs (both drawing process and picture products) and their verbalizations while engaged in computer activity has given support to the researcher's belief that boys and girls are experiencing the computer in different ways. From these findings, a speculation might be drawn that the girls' trend of talking more contributes to their drawing and bouncing the delta less often, and the boys' drawing and bouncing of the delta more often contributes to their verbalizing less frequently.

The most significant findings that boys were bouncing the delta and drawing more than the girls, perhaps instead of talking, and the pattern suggesting that girls were talking more than the boys (the girls significantly made more color and fill references than the boys), perhaps in lieu of drawing and bouncing the delta cursor, may be

indicative of gender-differentiated styles of interacting with the computer or different approaches to using this tool. Giving credence to this hypothesis are the visual representations of the preschoolers' computer drawings which tend to reflect creative diversity in boys and girls' computer graphic designs and differences in what each gender considers attractive qualities.

Frank (1983) questioned whether "girls are better at computer details, too?" She also speculated on whether the differences in their approaches to computer graphics activity are inherent or socialized. Looking at the present study, perhaps a connection could be made that the boys' bouncing of the cursor and the girls' verbalizing are tied to the well documented sex differences that boys are more aggressive and girls are more verbal (Maccoby and Jacklin, 1974). The bouncing of the delta may be the only thing available in the Delta Drawing program with which boys can be aggressive, especially since you have to "draw" or move (Delta Drawing command "M") the delta into the borders in order for it to bounce off the edges of the drawing screen. For the boys, there may be somewhat of a video game appeal in bringing the delta right up to the border and watching it bounce off.

Girls, on the other hand, in interacting with the computer may be doing something which is more comfortable for them; perhaps they are bringing a social side to the computer. And while quantitatively girls are not significantly doing as much as the boys, qualitatively their drawing products are just as, if not more, creative and significant. Each gender (as well as each individual child) may be using the computer and the program to do what he or she really wants to do.

The present thesis explored the topic of possible sex differences in use of the computer at the preschool level. Most importantly, it was questioned whether there are differences in the nature or the style in which young girls and boys interact with the computer. While hypotheses were not tested, qualitative impressions stemming from the pilot study and Alexander's research (1984) on preschool children's computer interactions were investigated. Quantitative analysis revealed more similarities than dissimilarities in preschool boys and girls' use of this particular computer graphics program. However, both quantitative and qualitative analysis of the data pointed to the possibility of an emerging pattern of gender differences in the children's styles of interacting with the computer and this specific computer graphics program. Further research needs to be conducted on this possible pattern of sex-differentiated styles with regard to young children's computer usage.

The findings of this study are not generalizable to the population of preschoolers using computers; they pertain only to this naturally occurring sample of preschool children using this particular interactive, computer graphics program. Further study of sex differences in preschoolers' use of the computer should include a larger sample of children, a more even ratio of the sexes, a more diverse background, for example, representation of different races and different social classes, and other types of interactive computer programs in addition to computer graphics. Also, control should be made for the sex of the experimenter, even though it is believed that children are attracted to the tool itself and not the teacher or experimenter's gender. Future study might include distinguishing the instructor of the

computer from the researcher to prevent possible experimenter bias.

A most significant addition to future research would be a longitudinal design to follow preschool boys and girls through elementary, middle and secondary school. This following of boys and girls' experiences with computers would contribute greatly to understanding how each gender approaches using the tool. Knowledge could thus be obtained as to how to maintain computer interest and usage among both sexes.

Despite the limitations of this study, the implications are far-reaching. Although hypotheses were not tested, hypotheses were generated for future investigation. Knowledge of how children are experiencing the computer can provide guidelines on how to implement computers into the early childhood classroom as well as into young children's lives. Knowledge of potential differences in the ways in which young children are interacting with the computer can help us understand how to facilitate both female and male attraction to the computer. Whether these potentially emerging, preferred styles of computer usage are by nature or nurture is not known as of yet and may be a topic for further study. Then again, the question of nature versus nurture perhaps should not be an issue. If children as well as adults are approaching the computer with gender-differentiated styles, then why not consider both approaches equally significant and equally worthy of being encouraged.

With this frame of mind, we can then discover ways to best prepare young boys and girls to use their unique forms of creative expression to

their fullest potential and to build up their confidence in their different approaches to using the computer. Such preparation will enable both girls and boys to continue pursuing computers during childhood, in the face of and past puberty, on throughout adulthood.

Before the inequities in computer access and usage become any greater, and prior to the potential emergence of another social stereotype portraying the computer as the male domain, it is imperative that the following message be widely publicized:

> The computer is a reality in our society that fits in with both females and males' approaches to work and life. The computer can be a wonderfully creative, equitable, nonsexist, thinking and learning tool if we really want it to be and as long as we make a conscious and dedicated effort to strive for this goal.

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APPENDICES

APPENDIX A

Delta Drawing Program
and
Instructional Script

DELTA DRAWING

Delta Drawing, according to its designers, is based on the simple principle that "kids love to draw." It is easy to learn and exciting to use. The child is in charge of creating pictures that are actually programs which can be edited, stored and recalled at any time. The authors state that, "Delta Drawing builds a child's confidence in operating a computer, stimulates creativity, and fosters intellectual development." Furthermore, it enhances children's visual thinking, and introduces them to procedural thinking.

The children in the Eliot-Pearson preschool summer class were instructed equally on thirteen of Delta Drawing's simple keyboard commands. They are as follows:

1. "D" for draw. A simple key press draws a tiny line, successive presses yield a long line.

2. "M" for move. This causes the Delta to detach from the line and move or jump away.

3. "R" for right. The delta turns to the right in angles of 30 degrees.

4. "L" for left. The delta turns 30 degrees to the left.

5. "C" for color. Upon pressing C, a menu of five colors appears on the bottom of the screen.

6. Color 1 is white. White can be used to only draw lines. All of the remaining colors can be used to draw lines as well as color in closed spaces.

7. Color 2 is orange.

8. Color 3 is blue.

9. Color 4 is green.

10. Color 5 is violet.

11. "F" for fill, and

12. "CTRL" -- pressed simultaneously they color in or "fill" shapes.

13. "E" for erase. This key allows editing of the picture program; pressed once and the previously chosen command is visually removed, pressed successively, lines and shapes, colors and fills can all be erased until the delta is back in the center of the screen where it originated.

Note: All Delta Drawing commands, save Erase, are recorded in the program's text which is saved with each picture.

Instructions to Preschoolers on how to create Computer Graphics
using Delta Drawing

Hi! My name is Elsa, and I'd like to show you how to draw on the computer. First, I'd like to know if you have ever used a computer before. Can you remember what you did?

Well, now I'd like to show you Delta Drawing. Here is the Delta; it's a small triangle. With the Delta, you can draw lines and all kinds of things. You do this by pressing some of the keys here. Have you ever seen a typewriter? Well, this is like a typewriter; it is a computer keyboard, and these are called keys. See the letters on top of the keys. We're not going to use all of the letters -- just a few of them, the ones with the stickers on them:

D, M, R, L, C, F and CTRL

We are also going to use some of the keys with numbers on them:

1, 2, 3, 4, 5.

First, we'll see what the letters do. With "D" you can draw; try pressing D. Press it again, several times; see the line. With "M" you can move away from the line. Press M, and watch the Delta move or jump away from the line. See; there's no line. But if you press D again, you'll get a line. Try it and see what happens.

Now if you want to go over here (pointing to the left side of the screen), you press "L" for left. See how the Delta has turned. Now try pressing "R" and see what that does. See where the Delta is pointing now? R turns the Delta to the right. And to draw again, you press D.

If you would like to change the color of your line, you can press "C" for color. This box here at the bottom of the screen is called a menu, and it gives you a choice of five colors. You can draw different colored lines by pressing 1 for white, 2 for orange, 3 for blue, 4 for green, and 5 for violet. Which color would you like to draw with?

You can also color in closed shapes (like this one here, pointing to a closed area). When we have no openings in our designs (traces with finger), we can fill in the picture with a color -- kind of like when we draw a circle or a square with crayons and then color it in. When using Delta Drawing, to color in a shape you say "Fill" which means to fill in the shape. Now the first thing you have to do is get the Delta inside the closed space. By pressing M for move you can move inside. Try moving inside here (pointing).

Now you press "C" for the color menu. When you fill you have only a choice of four colors to color in your shape. You can use orange, blue, green or violet, but not white because it can only be used for drawing lines. Which color would you like to use to fill in your shape?

Now to fill you press the "F" key for fill and this button, "CTRL" called control. Press CTRL first, then F, and hold them down at the same time. Look at what this does.

Now when you've finished drawing, you press your picture number; this tells the computer you're done and it closes your drawing. If you press your picture number again, you'll be able to see your drawing again. See.

I hope you liked drawing on the computer. Did you have fun/a nice time? Thank you for drawing on the computer.

Shapes Task:

Before you start on your shape, I'd like to show you this key here. If you press "E" you can erase the last thing you just did on the computer. You can use this key if you want to make any changes to your shapes.

APPENDIX B

Newsletter to Parents
Statement of Research Query

Newsletter to Parents

Plans in the making for Session II:

The Traveling Zoo, sponsored by the Metropolitan District Commission in conjunction with the Stone Memorial Zoo, will arrive on our doorstep on Monday, July 2 - weather and conditions permitting. Children will be taken on tours of the twelve exhibits consisting of birds, mammals, reptiles and some domestic animals. The animals will be housed in a large trailer to be parked near the side entrance to the school. We hope this anticipated treat will be able to make an appearance.

Children will be invited to join students enrolled in David Alexander's Science and Technology Course for hands-on experiences in the Curriculum Resource Lab and on our playground. This opportunity will start on June 11th and continue on Mondays and Wednesdays during Session II.

Elsa Jones, a student in the Child Study Department, will be joining us on a daily basis in order to provide Apple II computer experiences in the classroom.

We are planning an excursion to Devereaux Beach, Marblehead, during the second week of summer school and will be asking for parent help in transporting children. Specific information will be provided soon after the beginning of Session II.

HERE'S TO MORE FUN AND SUN !!!

Statement of Research Query

This study investigates sex differences in preschool children's use of the computer. The computer will be introduced as part of the curriculum in a summer school program at the Eliot-Pearson Children's School. Children, ages three through six, will have equal access to the computer which will be offered as a choice activity. The children will be observed interacting with the computer while engaged in a computer graphics (drawing) program. Behaviors will be coded according to a checklist, and the interacting child's dialogue will be tape recorded.

Interest in this topic developed out of a concern expressed by parents and teachers (reported in computer magazines) that the computer may be regarded as a male domain, even by young children. There exists very little published research on children and computers, although there are reports of some sex differences in young children's computer use.

It is expected that this study will reveal sex differences in preschool children's computer interactions, however, individual differences are predicted to be just as, if not more, significant.

Elsa E. Jones
Child Study
M.A. Graduate Student
27 June 1984

APPENDIX C

Date: _____

Session # _____

OBSERVER LOG

Child's Name and Age: _____

Child's Sex: _____ Female _____ Male

Visit # _____ Delta Drawing # _____

Time child-computer interaction began: _____

Time child-computer interaction ended: _____

Total time child interacted w/computer: _____mins.

Drawing Description

Child's Verbalizations (to researcher, observing peers, computer)

Researcher's Observations and Comments

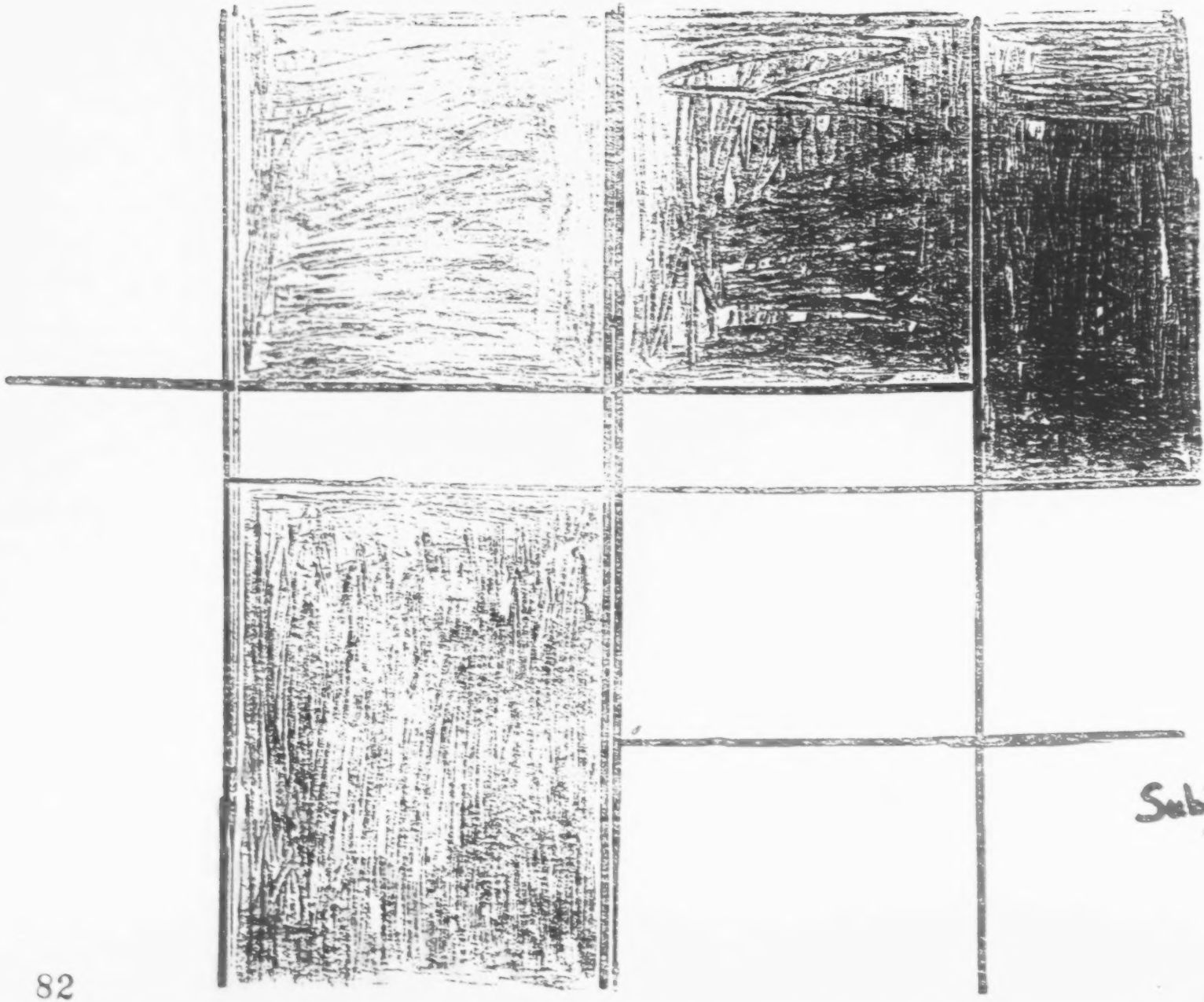
Previous computer experience?

"Block Construction"
with colored line

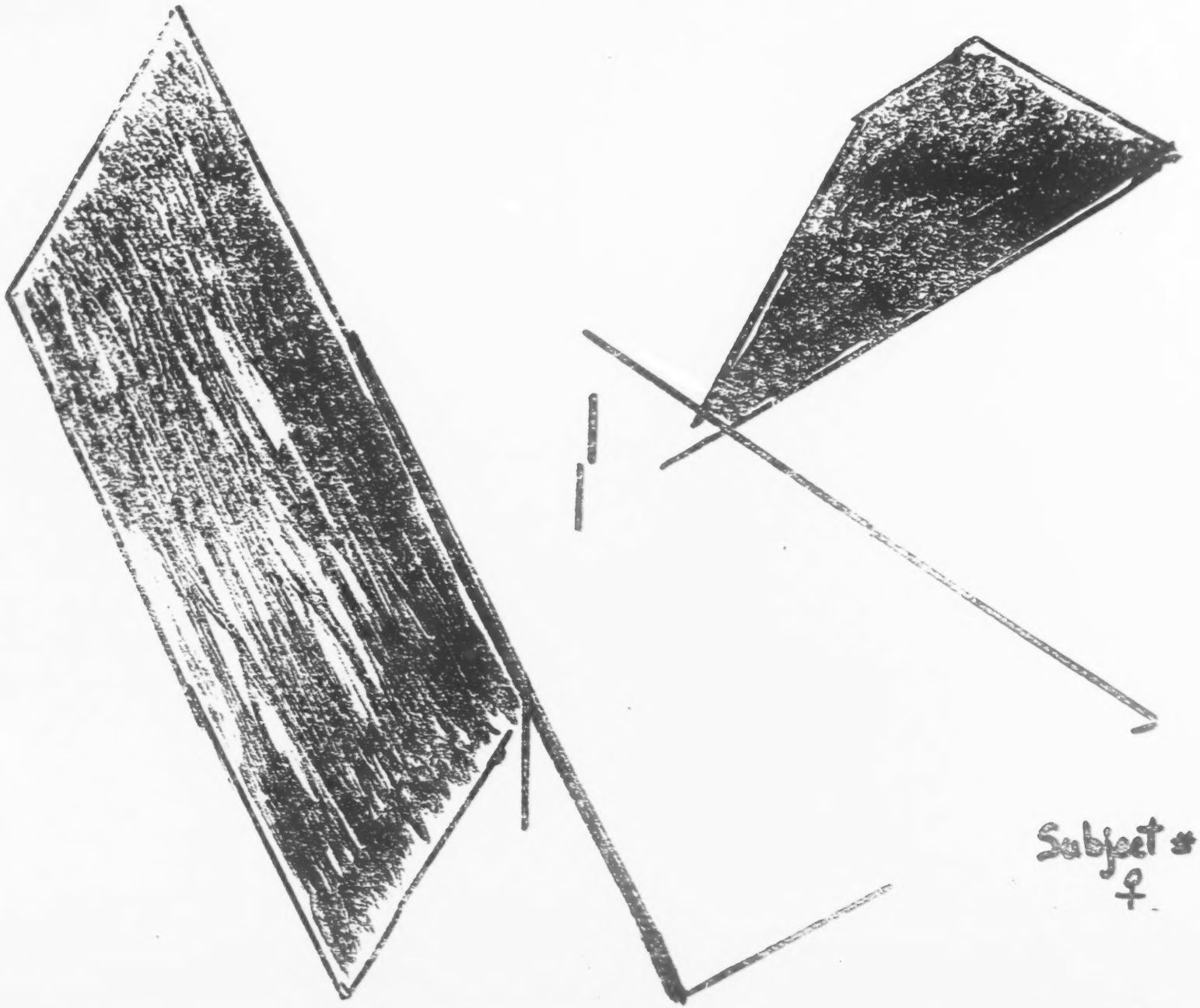
Subject = 2
♂

81

"[illegible] Construction"
using several line colors and
one color to fill

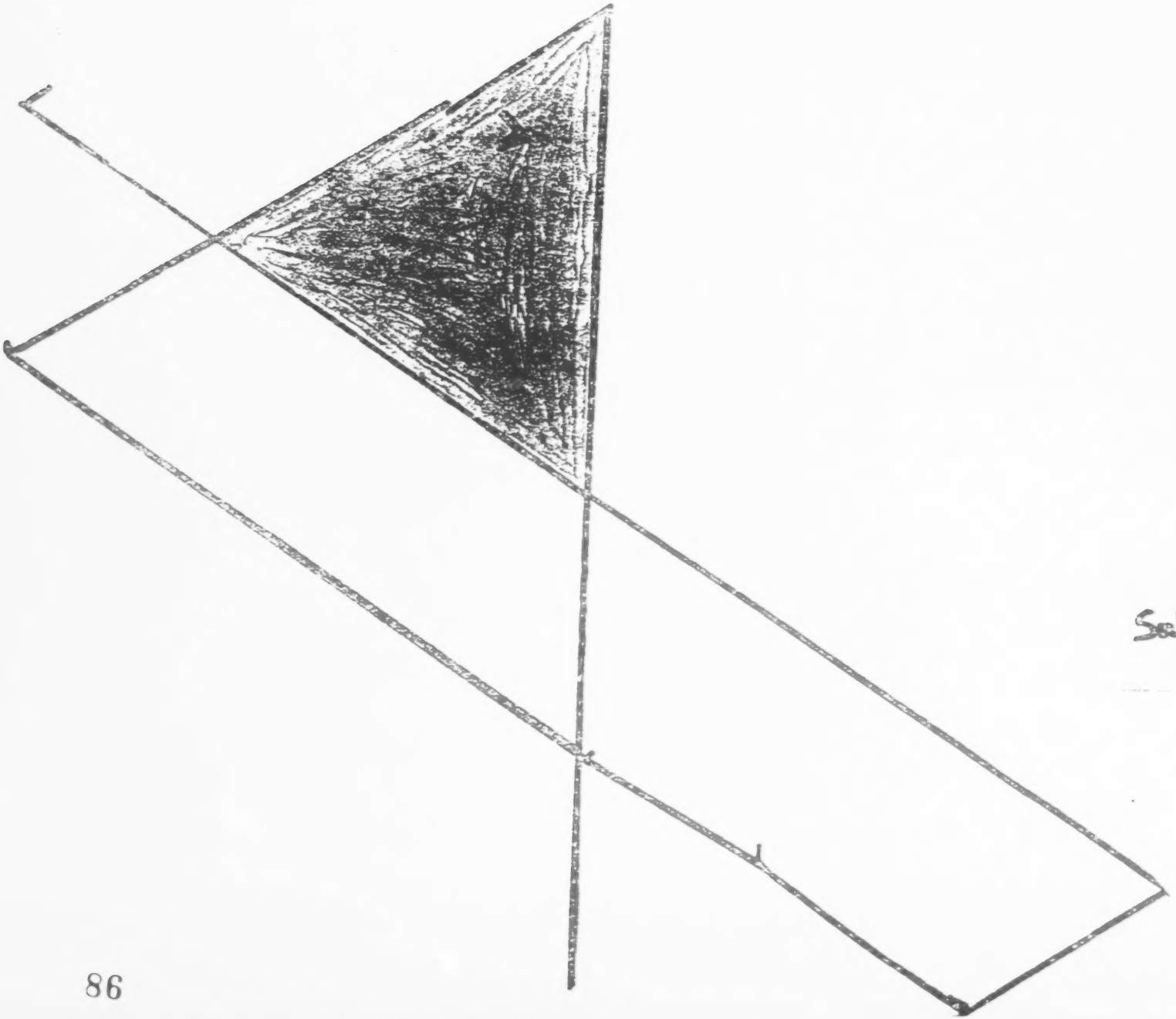


Subject #4
6



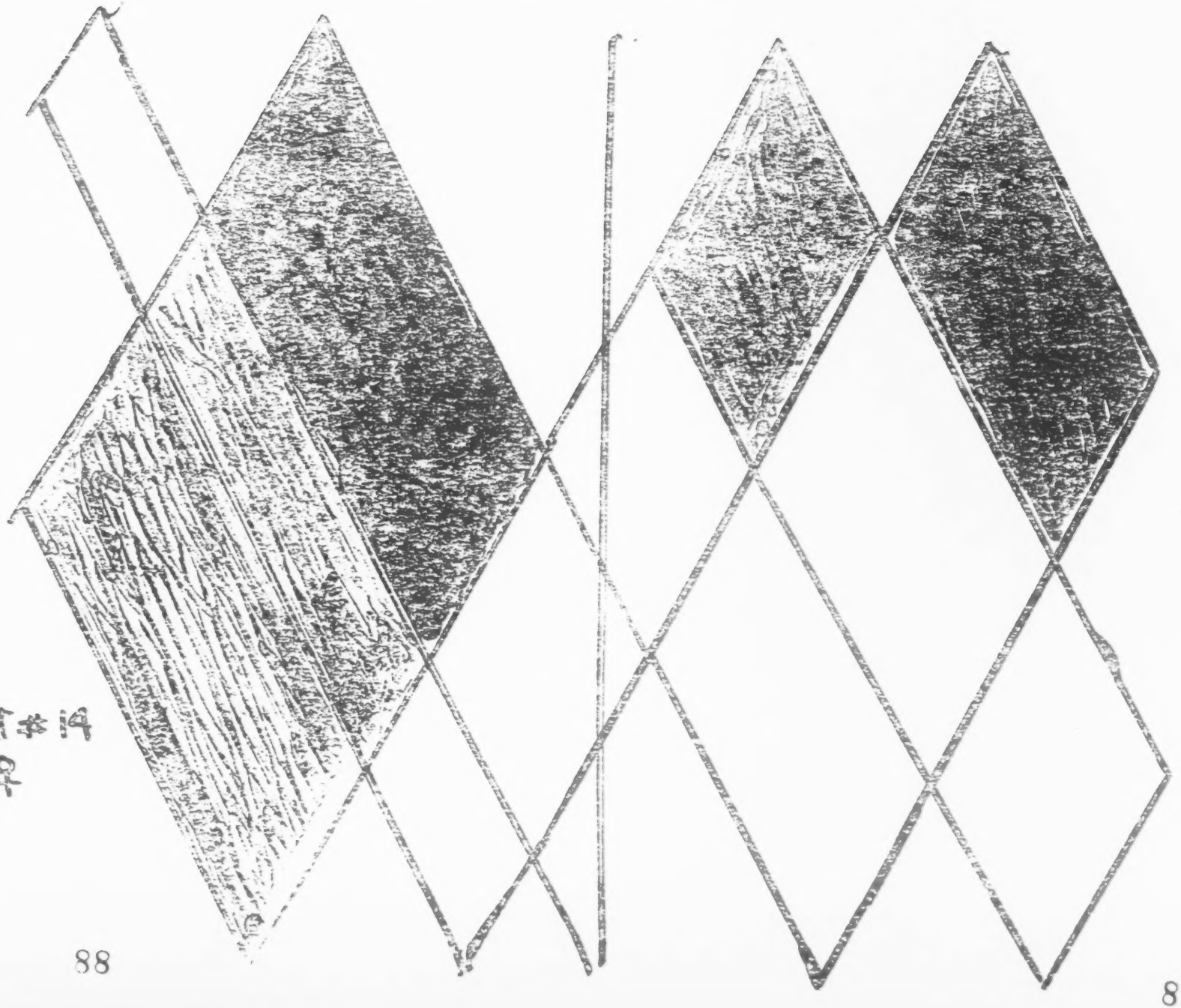
Subject # 5
♀

Beginning of Argyle Pattern
with colored lines and fill



Subject #10
♀

Argyle
using several line and fill colors



Subject # 19
9+